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"Infrared Observations of Comets Halley and Wilson and Properties of the Grains"

Cometary Dust Size Distributions from Flyby Spacecraft

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Prior to the Halley flybys in 1986 the distributions of cometary dust grains with particle size were approximated using models which provided reasonable fits to the dynamics of dust tails, anti-tails, and infrared spectra. These distributions have since been improved using fluence data (i.e., particle fluxes integrated over time along the flyby trajectory) from three spacecraft. We fit these data using the dust particle mass m and the dummy variable

$$x = (m/m_t)^{1/\gamma}$$

in the form

$$F = F_t \left[(1+x)^{\beta-1} / x^\beta \right]^{\alpha\gamma}$$

for the cumulative fluence. Here the transition mass m_t separates sizes for which the relevant power law exponents have the values α , $\alpha+1$, 3α , and $3\alpha+1$ (for cumulative mass, incremental mass, cumulative radius, and incremental radius distributions, respectively, at large mass) from those for which they have the smaller values $\alpha\beta$, $\alpha\beta+1$, $3\alpha\beta$, and $3\alpha\beta+1$ (at small mass). Typical values of $\beta=0.2$ for the data (as contrasted with $\beta=0$ for the predicted model) reflect the rich abundance in the coma of particles smaller than several tenths of a micron diameter. This result is illustrated by the entries in the table below. The particle outflow velocities also play a role in deriving the production distribution of the grains at the nucleus surface. The fluence-derived distributions are appropriate for comparison with simultaneous infrared photometry (from Earth) because they sample the particles in the same way as the IR data do (along the line of sight) and because they are directly proportional to the concentration distribution in that region of the coma which dominates the IR emission.

Fluence	α	β	γ	m_t (kg)	F_t (m^{-2})
Model	0.955	0.0	1.0	2.13×10^{-15}	2.9×10^8
<i>Giotto</i>	0.94	0.19	1.0	2.0×10^{-14}	8.07×10^6
VEGA-1	1.19	0.218	1.9	1.0×10^{-12}	1.43×10^6
VEGA-2	0.90	0.29	2.16	1.6×10^{-13}	9.8×10^5

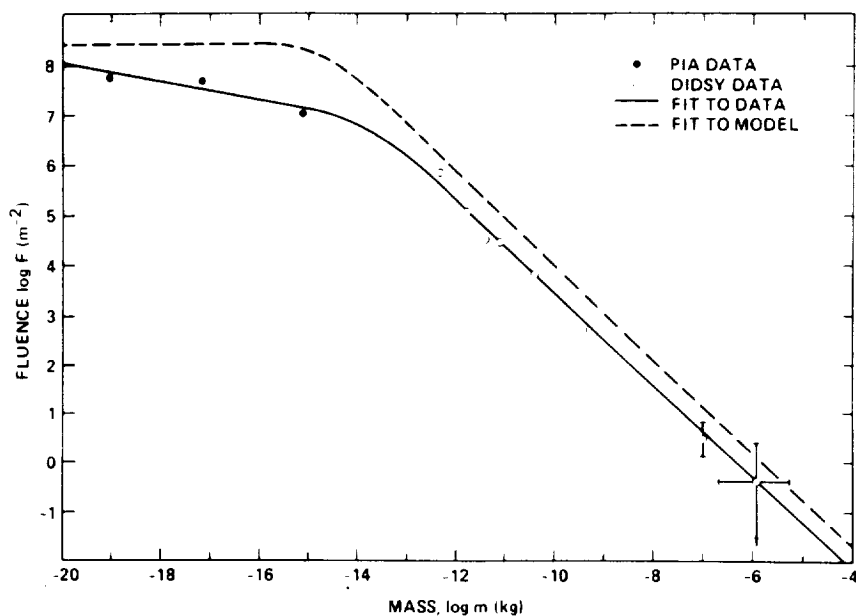


Figure 1. Sample cometary mass distributions from model and as fitted to fluence data from Giotto. Parameter values for the dashed and solid lines, respectively, appear in the first and second rows of the Table.

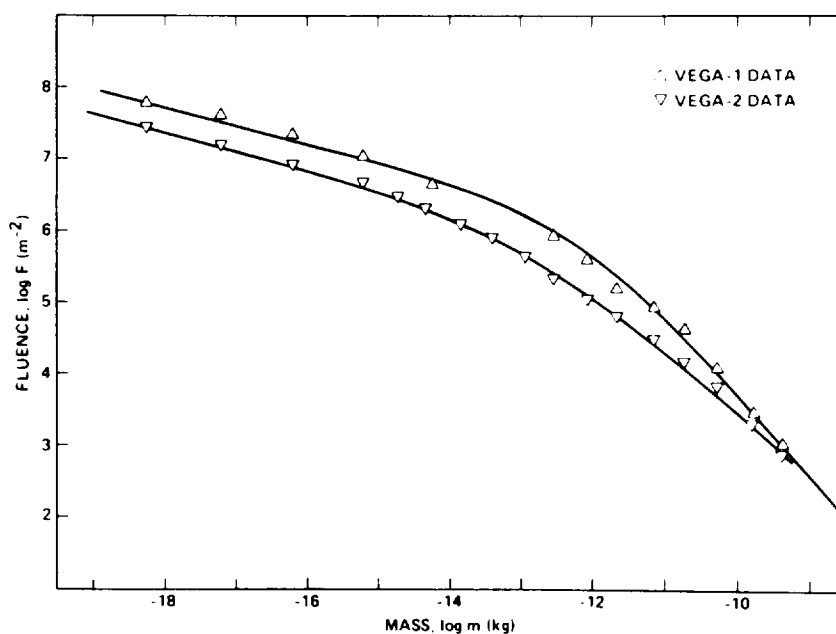


Figure 2. Sample cometary mass distributions fitted to fluence data from VEGA-1 and VEGA-2 SP-2. Parameter values appear in the third and fourth rows of the table.